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| Applicant: | Kiyoshi SHINOMIYA |
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## PERFECTION OF CLAIM FOR CONVENTION PRIORITY

Commissioner for Patents
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Sir:

The benefit of the filing date of the following prior foreign application filed in the following foreign country was requested in a claim for convention priority that was filed on March 2, 2007, where the right of priority provided in 35 U.S.C. §119 was claimed.

In order to perfect that claim, filed herewith is a verified translation of the original foreign application:

- Japan Patent Application No. 2003-044198 filed February 21, 2003.

Respectfully submitted,

Date April 9, 2009

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# VERIFICATION OF TRANSLATION

Patent Application No. 2003-044198

in Japan

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am the translator of the documents attached and I verify that the attached is a true translation to the best of my knowledge and belief.

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[Title of the Invention] Data Transfer Method and Network System

[Claim or Claims]

[Claim 1] A data transfer method executed in a network system in which a plurality of computers are connected to each other through a packet switched network, characterized in that

each of the plurality of computers includes a main storage device, a processor for issuing a communication process command, and a communication device for processing the communication command from the processor and communicating with another one of the computers through the packet switched network,

the communication device includes a transmission section for transmitting a communication to the switched network and a reception section for receiving a communication from the switched network,

each of the transmission section and the reception section includes a TLB for retaining a plurality of TLB entries,

the processor issues the communication command which includes information of the computer of the sending source, and

the reception section determines one of the TLB entries which is to be used in accordance with the computer of the sending source.

[Claim 2] A data transfer method as claimed in claim 1, characterized in that the transmission section produces a communication packet including the information of the computer of the sending source, and transmits the communication packet to another one of the computers.

[Claim 3] A data transfer method as claimed in claim 1 or 2, characterized in that the communication device limits the number of communication commands to be processed simultaneously to the same destination computer from the computer of the sending source to execute processing.

[Claim 4] A data transfer method as claimed in claim 2 or 3, characterized in that the communication device applies an identification number of a processing command in the computer of the sending source to a communication packet, and the reception section uses the same TLB entry for different communication packets which have the same identification number of the processing command.

[Claim 5] A network system in which a plurality of computers are connected to each other through a packet switched network, characterized in that

each of said computers includes a main storage device, a processor for issuing a communication process command, and a communication device for processing the communication command from said processor and

communicating with another one of said computers through said packet switched network,

said communication device includes a transmission section for transmitting a communication to said switched network and a reception section for receiving a communication from said switched network,

each of said transmission section and said reception section includes a TLB for retaining a plurality of TLB entries,

said processor issues the communication command which includes information of the computer of the sending source, and

said reception section determines one of the TLB entries which is to be used in accordance with the computer of the sending source.

[Claim 6] A network system as claimed in claim 5, characterized in that said transmission section produces a communication packet including the information of the computer of the sending source, and transmits the communication packet to another one of said computers.

[Claim 7] A network system as claimed in claim 5 or 6, characterized in that said communication device limits the number of communication commands to be processed simultaneously to the same destination computer from the computer of the sending source to execute processing.

[Claim 8] A network system as claimed in claim 6 or 7, characterized in that said communication device applies an identification number of a processing command in the computer of the sending source to a communication packet, and said reception section uses the same TLB entry for different communication packets which have the same identification number of the processing command.

[Detailed Description of the Invention]

[0001]

[Technical Field to Which the Invention Belongs]

The present invention relates to a network system wherein a plurality of computers parallelly execute processing of individual jobs thereof while communicating with each other, and a data transfer method for a computer system.

[0002]

[Background Art]

As a result of popularization of system area networks, distributed computing systems have been and are increasing wherein a plurality of computers are connected to each other by a high speed network and parallelly execute processing of individual jobs thereof while communicating with each other.

[0003]

The parallel processing by a plurality of

computers makes it possible to execute a large scale arithmetic operation process which cannot be implemented by a single computer. Also the HPF (High Performance Fortran) which is a standard program language for programming or the MPI (Message Passing Interface) which is a library where a plurality of computers perform arithmetic operation while communicating with each other has been developed, and the parallel processing is used in a progressively increasing wide region and computers having the function are increasing.

[0004]

Where a plurality of computers are connected to each other by a network and execute parallel processing through mutual communication, at least an arithmetic operation process of performing an actual arithmetic operation and a communication process of performing communication with another computer are required.

[0005]

When a communication process is performed, if a processor performs the communication process, then the arithmetic operation capacity of the processor is deteriorated by the communication process. In order to use the arithmetic operation capacity of the processor for the arithmetic operation as much as possible, a communication device is sometimes incorporated while removing the communication process from the processor.

[0006]

The communication device processes a communication command from the processor and transfers data of a sending source designated by the communication command to a destination designated by the communication command. The communication command usually designates a sending source address which is an address on a main storage of sending source data, a transfer length which is a length of the data to be transferred and a computer of the sending destination.

[0007]

The designations of the sending source address, transfer length and sending destination computer in the communication command are called Send command. In addition, the designation of a sending destination address which is a main storage address of the sending destination is called Remote DMA Write command.

[0008]

If the address on the main storage designated by the communication command is a physical address, then a process of forwarding the communication command to the communication processing device is limited to a privileged process to which a physical address can be known. When a user level process which is a non-privileged process performs a communication process, it issues a request for communication to a privileged

process, and the privileged process executes a process of converting a logical address into a physical address by proxy through a process switch. Since such a process switch process as just described requires a very long period of time as viewed from the user process, the process switch process makes one of factors of performance degradation.

[0009]

In order to prevent the performance degradation by the process switch process described above, the communication device incorporates an address conversion mechanism for converting a logical address into a physical address so that the user process can issue a communication command to the communication device without intervention of a privileged process. This is called user level communication and is implemented by a network apparatus for which communication of a high performance with a low latency is required.

[0010]

When the address conversion mechanism is incorporated, a method is adopted wherein an address conversion table is fully incorporated in the communication device. However, where the address conversion table cannot be incorporated in the communication device, another method is adopted wherein the address conversion table is incorporated in a memory

outside the communication device and part of the address conversion table is incorporated as a TLB (Translation Look aside Buffer) in the communication device.

[0011]

Usually, the following three methods are available to incorporate a TLB:

[0012]

(1) Full associative method wherein a conversion object logical address is used for comparison of part of logical addresses of all TLB entries and a TLB entry which exhibits coincidence is used for address conversion;

(2) Direct map method wherein some of bits of a conversion object logical address are used as an address of a TLB entry to be used for conversion; and

(3) Set associative method wherein a set of some TLB entries are selected from among all TLBs using some of bits of a conversion object logical address and the logical addresses in all of the TLB entries in the selected set and the conversion object logical address are compared with each other.

In all of the methods described, a conversion object logical address is used for determination of a TLB entry.

[0013]

Where a method wherein a TLB is incorporated is adopted, the hit ratio of the TLB has a significant

influence on the transfer performance. Therefore, it is expected to raise the hit ratio of the TLB incorporated in the communication device.

[0014]

A communication device which performs address conversion is disclosed, for example, in patent references 1 to 3. Patent reference 1 (Japanese Patent Laid-Open NO. 05-089056) discloses an apparatus wherein a shared memory which performs address conversion is accessed through communication control.

Patent reference 2 (Japanese Patent Laid-Open No. 07-262146) discloses another apparatus wherein address conversion is performed by a router and inter-processor communication is performed using a packet. Patent reference 3 (Japanese Patent No. 3,237,599) discloses a further apparatus wherein address conversion is performed in a processor.

[0015]

[Patent Reference 1]

Japanese Patent Laid-Open NO. 05-089056

[Patent Reference 2]

Japanese Patent Laid-Open No. 07-262146

[Patent Reference 3]

Japanese Patent No. 3,237,599

[0016]

[Problem to be Solved by the Invention]

As described hereinabove, where a

communication device according to the TLB method is incorporated in a computer in order to implement parallel processing using a plurality of computers, improvement of the hit ratio of a TLB is a significant subject.

[0017]

As described above, in order to incorporate a TLB in a communication device, usually the direct map method, set associative method or full associative method is used wherein a conversion object logical address and logical addresses in TLB entries are compared with each other.

[0018]

According to the three methods, a TLB entry to be used for conversion is determined based on a conversion object logical address. Further, since the number of TLB entries is smaller than the size of the address conversion table, replacement of a TLB entry is performed when a miss occurs with the TLB and besides the TLB does not include a free entry.

Since the logical addresses used by a processor have a high locality and exhibit such a behavior that there is a high degree of possibility that a logical address used recently may be used again, the LRU (Least Recently Used) algorithm, that is, an algorithm which replaces a TLB which has been least used recently is used frequently as an algorithm for the

replacement.

[0019]

In data transfer, however, the write object address in most cases increases monotonously, and the main storage address indicates a behavior much different from the behavior in accessing of the processor that the possibility that a main storage address used in the past may be re-utilized is low. Therefore, there is a first problem that, if the LRU is used as the replacement algorithm for a TLB entry, then the TLB hit ratio is dropped thereby.

[0020]

Further, since a TLB held by a reception section of a communication device is used for communication with a plurality of opposite parties, if a TLB entry which is used only with a logical address is used, then all of the TLB entries of the reception section of the communication device are used in response to data transfer from a transmission apparatus of one opposite party of communication and replace those TLB entries which have been used by data communication of transmission apparatus of other opposite parties of communication. Therefore, there is a second problem that the TLB hit ratio is dropped thereby.

[0021]

It is an object of the present invention to provide a method by which the hit ratio of a TLB which

is incorporated in a communication device and serves as an address conversion device for implementing user level communication in a computer system wherein each of a plurality of computers communicates with another computer through a communication device thereof is improved and the device can be used efficiently.

[0022]

[Means of Solution to the Problem]

A data transfer method and network system of the present invention are characterized in that in the data transfer method executed in the network system in which a plurality of computers are connected to each other through a packet switched network,

each of the plurality of computers includes a main storage device, a processor for issuing a communication process command, and a communication device for processing the communication command from the processor and communicating with another one of the computers through the packet switched network,

the communication device includes a transmission section for transmitting a communication to the switched network and a reception section for receiving a communication from the switched network,

each of the transmission section and the reception section includes a TLB for retaining a plurality of TLB entries,

the processor issues the communication command

which includes information of the computer of the sending source, and

the reception section determines one of the TLB entries which is to be used in accordance with the computer of the sending source.

[0023]

The transmission section adds information of the computer of the sending source, which is contained in the communication command, to a communication packet, or adds information of the self computer, which is held by the communication device, to a communication packet.

[0024]

When the communication device limits the number of communication commands to be processed simultaneously to the same destination computer from the computer of the sending source to execute processing, and the transmission section simultaneously processes a plurality of communication commands to the same destination computer, transmissions can be made overlap with each other and a high TLB hit ratio can be achieved.

[0025]

The communication device applies an identification number of a processing command in the computer of the sending source to a communication packet, and the reception section uses the same TLB entry for communication packets which have the same

identification number of the processing command. With the configuration, a TLB entry selection logic to be used by the reception section can be simplified.

[0026]

"Effects"

In the present invention, in order to raise the hit ratio of a TLB incorporated in a reception section of a communication device, the TLB of the reception section of the communication device retains one entry or a plurality of TLB entries for exclusive use independently for each of sending source computers of a communication request for a TLB entry. When a communication destination logical address from the same sending source misses on the TLB and the TLB entry or entries assured exclusively for the sending source computer are not free, only the TLB entry or entries exclusively for the sending source computer are determined as a rewriting object.

[0027]

Consequently, unintended driving out of a TLB entry by a communication from another sending source can be prevented, and besides, a replacement object of the TLB can be selected readily.

[0028]

Further, the sending source computer of a communication request limits the simultaneous process command number for communication commands to the same

destination computer to a number equal to or smaller than a prescribed number and a number of TLB entries equal to or greater than the simultaneous process command number are incorporated in the communication device on the reception side and besides a TLB entry or entries are allocated exclusively for each communication command. Consequently, when a plurality of communication packets transmitted based on a plurality of communication commands are received from a plurality of sending source computers, the possibility that driving out of a TLB entry being used in the communication may occur is reduced, and the TLB hit ratio is improved.

[0029]

[Mode of Carrying Out the Invention]

An embodiment of the present invention will be described next with reference to the accompanying drawings.

[0030]

Fig. 1 is a block diagram showing the configuration of a system according to the embodiment of the present invention.

[0031]

The system shown in Fig. 1 includes computers 100a to 100z which are connected to each other through a switched network 500 to perform communication. Each of the computers 100a to 100z includes a processor 200a to

200z for issuing an instruction to perform an arithmetic operation process or a communication process, a main storage device 300a to 300z for retaining data to be used by the processor 200a to 200z to perform its processing, and a communication device 400a to 400z for processing a communication command from the processor 200a to 200z and performing a communication process through the switched network 500. Each of the communication devices 400a to 400z includes an RTLB 410a to 410z and an STLB 470a to 470z for converting a logical address into a physical address.

[0032]

Fig. 12 is a block diagram showing an internal structure of the computers. In Fig. 12, the computers 100a and 100b are shown as representatives, and the internal structure only of the computer 100a is shown. Since all of the computers 100a to 100z operate similarly, in the following description, the processor 200a, main storage device 300a, page table 310a for address conversion in the main storage device 300a, communication device 400a, RTLB 410a and STLB 470a shown in Fig. 12 are denoted as a processor 200, main storage device 300, page table 310, communication device 400, RTLB 410 and STLB 470, respectively.

[0033]

The communication device 400 includes a transmission section 450, a STLB 470 which is a TLB for

the transmission section, a RTLB 410 which is a TLB for a reception section, and a reception section 460.

[0034]

The transmission section 450 extracts, in accordance with an instruction from the processor 200, a communication command from the main storage device 300 and converts a logical address of sending source data in the communication command into a physical address by means of the STLB 370 which retains part of contents of the page table 310. Then, the transmission section 450 extracts transmission data from the main storage device 300, produces a communication packet from the extracted data and the communication command, and transmits the communication packet to a designation computer through the switched network 500.

[0035]

The STLB 470 temporarily stores a page entry including the logical address received from the transmission section 450 and page attributes extracted from the page table 310 in the main storage device 300 in order to convert the logical address into a physical address.

[0036]

The RTLB 410 temporarily stores a page entry including a destination logical address in a communication packet and page attributes extracted from the page table 310 in the main storage device 300 in

order to convert the destination logical address into a physical address.

[0037]

The reception section 460 receives a communication packet from the switched network 500 and uses the RTLB 410 to perform conversion of a destination logical address into a destination physical address, and then writes data in the communication packet into the destination physical address of the main storage device 300.

[0038]

The contents of the page table 310 are described with reference to Fig. 4. A page table is assured for each of processes which involve communication, and the page tables are disposed on the main storage device 300. Thus, the page tables 310 are used for conversion from a logical address into a physical address. Since a logical address is provided independently for each process, a page table 310 to be used is determined based on a process number. A logical address includes an offset in a page of a size determined in advance and a logical page number called VPN (Virtual Page Number).

For example, where the page size is 4 Kbytes while a logical address has 64 bits (63 to 0), the VPN indicates a logical address portion (63-12) and the offset indicates a logical address portion (11-0). The

physical address after the address conversion includes the VPN replaced with a physical page number called PPN (Physical Page Number) and the offset which is not altered.

[0039]

The page table 310 includes a plurality of page entries 330 wherein the VPN mentioned above indicates the page entry number of the TLB to be used. In particular, if the VPN is 30, then the page entry of the 30th TLB is used. Each page entry 330 includes a PPN 320 which is a page number after the address conversion, a readability attribute 322 representing that the page after the address conversion is readable, a writability attribute 323 representing that the page is writable, and an entry validity flag 321 representing that the contents of the page entry are valid.

[0040]

Fig. 10 is a diagrammatic view illustrating an example of a format of a communication command with which the processor 200 instructs the communication device 400.

[0041]

One communication command 800 includes a command code 810 representative of a function code of the command, a destination computer number 811 representative of a destination computer, a destination process number 812 representative of a destination

process, a destination logical address 813 representative of a write address of data in the destination process, a transfer length 814 representative of the length of the data to be transferred, a sending source computer number 815, a sending source address 816 representative of a logical address of the data to be transferred in a sending source process, and a process number 817 representative of a process of the sending source.

In the command code 810, where a logical address in the destination computer is to be designated, a function code of Remote DNA Write is designated, but where an address of the reception section which retains a logical address in the destination computer is to be used, a function code of Send is designated. Where the command code 810 indicates Send, the destination logical address 813 is invalid.

[0042]

Fig. 11 is a diagrammatic view illustrating an example of a format of a communication packet which is transmitted from the communication device 400 which receives the communication command 800 illustrated in Fig. 10 to the switched network 500 or is received from the switched network 500 by the communication device 400.

[0043]

One communication command 800 illustrated in

Fig. 10 is transmitted divisionally in a plurality of communication packets 900 in order to assure the reliability of communication and simplify the structure of the communication device 400.

[0044]

Each communication packet 900 includes a command code 910 to which the command code 810 of the communication command is set, a destination computer number 911 to which the destination computer number 811 of the communication command 800 is set, a process number (PPID: Packet Process ID) 912 indicative of a process of an opposite party of communication to which the destination process number 812 of the communication command 800 is set, a destination logical address (PVA: Packet Virtual Address) 913 indicative of a writing destination of data in a destination process to which the destination logical address of the packet is set, a data length 914 to which the length of the data of the packet is set, a sending source computer number 915 for identification of a sending source to which the sending source computer number 815 of the communication command 800 is set, and data 917 for being written into the destination.

[0045]

When the communication command maximum simultaneous process number which indicates a number of processes simultaneously to the same destination from

the transmission section 450 of the communication device 400 for transmission to the switched network 500 is set to two or more, the transmission section 450 adds a command identification number 916 indicative of an identification number of a command to be processed simultaneously to the communication packet to designate a TLB entry to be used by the reception section 460 thereby to raise the TLB hit ratio upon simultaneous processing of a plurality of communication commands to the same destination by the transmission section 450.

[0046]

Fig. 2 is a diagrammatic view illustrating a configuration of the RTLB 410 incorporated in the communication device 400. The RTLB 410 includes a plurality of TLB entries wherein one or a plurality of entries are prepared for each of sending source computers of received packets from the switched network. One TLB entry includes a TLB entry validity flag 420, a process number (TPID: TLB Process ID) 421, a virtual page number (TVPN: TLB Virtual Page Number) 422, and a physical page number (TPPN: TLB Physical Page Number) 423.

[0047]

Fig. 3 is a diagrammatic view illustrating an address conversion method of converting a logical address of the communication device 400 into a physical address.

[0048]

The reception section 460 which accepts the communication packet 900 illustrated in Fig. 11 produces a physical address from the destination process number (PPID: Packet Process ID) 912 and the destination logical address (PVA: Packet Virtual Address) 913.

[0049]

The PVA 913 includes a virtual page number (PVPN: Packet Virtual Page Number) 921 and an offset (Offset) 922. The PPID 912 and the PVPN 921 are compared with the TPID 421 and the TVPN 422 of a TLB entry corresponding to the communication packet 900, respectively. When both of two results of the comparison exhibit coincidence and the TLB entry validity flag 420 indicates validness, a TLB hit is detected and an after-conversion physical address 932 is produced from the TPPN 423 and the Offset 922.

[0050]

By the procedure described, address conversion from the PPID 912 and the PVA 913 into the physical address 932 is performed.

[0051]

Fig. 4 is a diagrammatic view for explaining an address conversion procedure where the results of comparison do not exhibit coincidence or where the TLB entry validity flag 420 does not indicate validness, that is, in the case of a TLB miss.

[0052]

Software which uses the communication device 400 is assured in advance in a region in the main storage device 300 in which the page table 310 to be used for conversion from a logical address into a physical address can be accessed by the communication device 400. One page table is used for one process. The page table 310 includes a plurality of page entries 330, and one page entry is used for address conversion for one page and includes, for each value of the PVPN 921 of a received packet which is part of a logical address to be converted, one PPN (Physical Page Number) 320, a readability attribute 322 indicating that the page after the address conversion is readable, a writability attribute 323 indicating that the page is writable, and an entry validity flag 321 indicating that contents of the page entry 330 are valid.

[0053]

The physical address produced by the address conversion is a combination of the PPN 320 and an offset which is an in-page address of the logical address. For example, where the logical address includes 64 bits and the page size is 4 Kbytes while the physical address includes 50 bits, the PPN 320 is a physical address portion (49-12) and the offset (11-0) forms a physical address portion (11-0). Here, the representation in each parentheses represents the bit positions and "-" in

the parentheses indicates the range of bits while the character on the left side of "-" indicates the MSB (Most Significant Bit) and the character on the right side of "-" indicates the LSB (Least Significant Bit). In short, (63-12) represents 52 bits from the bit position 63 to the bit position 12.

[0054]

If such a TLB miss as described hereinabove occurs, then the communication device 400 registers the PPID 912 and the PVPN 921 of the communication packet 900 into the TPID 421 and the TVPN 422 of the entry with which the TLB miss has occurred. Then, the communication device 400 updates the page entry 330 read out from the page table 310 in accordance with the PVPN 921 with the TPPN 423 of the TLB entry, and sets the value of the read out page entry validity flag 321 to the TLB validity flag 420.

[0055]

After the TLB entry validity flag 420 is set, the RTLB 410 is re-indexed with the communication packet 900.

[0056]

The PPID 912 and the PVPN 921 in the communication packet 900 are registered in the TPID 421 and the TVPN 422, respectively, and when the TLB entry validity flag 420 indicates validness, the communication packet 900 hits on the TLB. Address conversion after

the TLB hit by the re-indexing is similar to that upon the hit on the TLB upon the first time indexing. If the TLB entry validity flag 420 indicates invalidness, an exception of address conversion occurs and the packet is abandoned, or such an exception process as to issue a notification of illegality to the transmission source of the packet is performed.

[0057]

Fig. 5 is a diagrammatic view for explaining a method of calculating a TLB index address.

[0058]

After the reception section 460 receives a communication packet 900 including the sending source computer number 915, PPID 912, PVA 913 and the communication data (Data) 917 for being written into the destination, if the value of the sending source computer number 915 is N, then the TLB entry N is taken out.

[0059]

The PVA 913 includes a PVPN 921 and an Offset 922. The TLB entry N is a TLB entry assured exclusively for the sending source computer and is not driven out by communication from any other sending source computer. Where the characteristic of data transfer that the destination address in most cases increases monotonously is taken into consideration, the TLB entry continues to hit on the TLB entry N before the value of the PVPN 921 of the destination address is altered. By the TLB

configuration described above, the TLB entry is not driven out by accessing from any other sending source computer.

[0060]

Fig. 6 is a diagrammatic view for explaining an implementation example wherein the transmission section 450 of the communication device 400 processes a plurality of communication commands to the same destination using the command identification number 916.

[0061]

A communication packet 900' shown in the present implementation example is characterized in that, to a communication packet 900 used in the TLB indexing method described hereinabove with reference to Fig. 5, an identification number 916 of a communication command to be processed simultaneously to the same destination is added by the transmission section so that it may be used for production of an indexing address of a TLB. The present implementation example is similar to that described with reference to Fig. 5 except that the command identification number 916 in the communication packet 900' is used for the TLB indexing address N.

[0062]

The reception section 460 of the communication device 400 which receives the communication packet 900' calculates, where the value of the sending source computer number 915 is j and the value of the command

identification number 916 is k while the number of communication commands to be processed simultaneously for the same destination by the transmission section of the communication device 400 is Pmax, the indexing address N of the TLB entry in accordance with the following expression (1):

[0063]

$$N = Pmax \times j + k \quad \ldots (1)$$

Where the command identification number 916 of the communication packet 900' is used for the TLB indexing address N, even when communication packets produced with a plurality of commands are transmitted simultaneously in an exchanged order to the communication device 400 of the same destination computer from the transmission section 450 of the communication device 400, driving out of the TLB entry can be prevented, and the hit ratio of the TLB can be raised.

[0064]

The TLB indexing and replacing operation is described below with reference to Fig. 13.

[0065]

S100: Start of TLB indexing. A logical address conversion operation of the packet 900 received from the switched network 500 is started.

[0066]

S110: An indexing address of the TLB is

produced by "Produce TLB indexing address". Where the simultaneous process communication command number is represented by Pmax and the value of the communication command identification number 916 is represented by k while the sending source computer number is represented by j, from the expression (1) given hereinabove,

$$\text{TLB indexing address} = \text{Pmax} \times j + k$$

is obtained. A TLB entry registered in the TLB indexing address is determined as an object entry, and the following processes are executed for the object entry.

[0067]

S120: A hit discrimination of a TLB is performed by "PVPN = TVPN?", and the destination process number PPID 912 of the received packet 900 and the PVPN 921 which is a virtual page number of the destination logical address 913 are compared with the values of the process number TPID 421 and the virtual page number TVPN 422 of the object entry of the TLB, respectively. If coincidence is exhibited with both of the PID and the VPN and besides the TLB entry validity flag 420 indicates validness, then a TLB hit is detected and the processing advances to step S130. In any other case, a TLB miss is determined, and the processing advances to step S200.

[0068]

The process just described is a process where the TLB is formed using the direct map method. Where

the TLB is formed otherwise using the set associative method, in the comparison described above, the TPIDs and the TVPNs of the TLB entries of all sets are compared with the PVPN and the PPID of the received packet, respectively. Where coincidence of one of the plural TLB entries is detected and besides the value of the TLB entry validity flag 420 of the TLB entry indicates validness, a TLB hit is determined, but when no such TLB hit is detected, a TLB miss is determined.

[0069]

Further, where the TLB is formed otherwise using the full associative method, the comparison is performed similarly to that where the set associative method is used except that the TVPNs of all TLB entries and the PVPN of the received packet are compared with each other.

[0070]

S130: When a TLB hit is determined at preceding step S120, a physical address is produced from the values of the physical page number TPPN 423 of the object entry of the TLB and the offset 922 which is an in-page address of the logical address of the received packet.

[0071]

S500: The physical address conversion of the received packet is completed with step S130, and the TLB operation is ended.

[0072]

S200: When a TLB miss is determined at step S120, it is checked whether or not the entry validity flag 420 of the TLB indicates validness. If the entry validity flag 420 indicates validness, the processing advances to step S210, but in any other case, the processing advances to step S220.

[0073]

S210: The entry validity flag 420 of the object entry in the TLB is cleared to a value indicative of invalidness to invalidate the entry.

[0074]

The description just above relates to a case wherein the TLB is formed using the direct map method. Where the TLB is formed otherwise using the set associative method or the full associative method, one entry is selected from among the plurality TLB entries using the LRU (Least Recently Used) method or the like, and the entry validity flag 420 of the selected entry is cleared to a value indicative of invalidness and the selected entry is determined as a processing object entry for later processing.

[0075]

S220: The value of the PVPN 921 of the received packet is set to the logical page number TVPN 422 of the object entry in the TLB.

[0076]

S230: The page entry 330 is taken out from the page table 310. The page entry 330 is indexed with the virtual page number PVPN 921 of the received packet.

[0077]

S240: The physical page number PPN 320 and the readability attribute 322 of an attribute flag, the writability attribute 323 and the page entry validity flag 321 extracted from the page entry 330 are registered into the object entry of the TLB.

[0078]

S250: Where the value of the page entry validity flag 321 read out as described hereinabove indicates validness and the writability attribute 323 is "1", the processing advances to step S110 in order to perform indexing of the TLB again. On the other hand, where the value of the entry validity flag 321 indicates invalidness or where the writability attribute 323 is "0" and indicates that writing is impossible, the page conversion results in failure, and the processing advances to step S500 in order to abandon the received packet and end the processing.

[0079]

Subsequently, the simultaneous parallel process of a plurality of communication commends to the same destination computer by the communication device 400 is described.

[0080]

As seen in Fig. 7, the communication device 400a communicates with the communication device 400b through the switched network 500. Fig. 8 is a diagrammatic view illustrating communication commands to be processed by the communication device 400a. In particular, the communication device 400a executes processes of communication commands 1 to 4 whose destination is the communication device 400b in accordance with a request from the processor. The communication commands 1, 2, 3 and 4 are divided into five, three, three and one packets, respectively, and sent to the communication device 400b through the switched network 500.

[0081]

Fig. 14 illustrates an example of packet transmission where the communication packets formed from the plural communication commands are transmitted in the order of the communication commands from the communication device 400a to the communication device 400b through the switched network 500. The communication commands 1, 2, 3 and 4 transmit five, three, three and one packets, respectively.

[0082]

At the transmission turn numbers 1 to 5 in the transmission order, the communication command 1 is transmitted divisionally in five communication packets 1-1 to 1-5; at the transmission turn numbers 6 to 8, the

communication command 2 is transmitted divisionally in three communication packets 2-1 to 2-3; at the transmission turn numbers 9 to 11, the communication command 3 is transmitted divisionally in three communication packets 3-1 to 3-3; and at the transmission turn number 12, the communication command 4 is transmitted in one communication packet 4-1. The last packets of the communication commands 1, 2, 3 and 4 are transmitted at the transmission turn numbers 5, 8, 11 and 12, respectively. In the example of Fig. 14, the simultaneous communication command process number is "2" and the communication packet internal command identification number assumes the value of 1 or 2, and the value of the identification number in the communication commands 1 and 3 is 1 while the value of the identification number in the communication commands 2 and 4 is 2.

[0083]

Fig. 9 is a diagrammatic view illustrating an example of transmission wherein the communication packets produced from the plural communication commands are transmitted in a complicated order from the communication device 400a to the communication device 400b through the switched network 500.

[0084]

In the example illustrated in Fig. 9, the number of communication commands which can be processed

simultaneously for the same destination by the communication device 400a is 2, and the incomplete communication command number of the production source of packets to be transmitted to the switched network 500 is "2" in the maximum. The incomplete communication command signifies a communication command whose last packet is not transmitted to the switched network. Further, the communication commands 1, 2, 3 and 4 of Fig. 9 are divided into the numbers of packets equal to those of the communication commands 1,2, 3 and 4 of Fig. 14, respectively. In other words, the communication commands 1, 2, 3 and 4 transmit five, three, three and one packets, respectively.

[0085]

At the transmission turn numbers 1 and 2 in the transmission order, the communication device 400a sets the command identification number of the communication packets 1-1 and 1-2 produced from the communication command 1 to "1" and sends the communication packets 1-1 and 1-2 to the switched network 500 thereby to place the command identification number "1" into a used state.

[0086]

At the transmission turn numbers 3 and 4, while the communication device 400a has not sent out all packets of the communication command 1, since the communication packets 2-1 and 2-2 produced from the

communication command 2 are ready and, even if the communication command 2 is processed, the simultaneous transmission command number remains within the simultaneous transmission command number limitation, the communication device 400a applies a command identification number different from the command identification number "1" already in a used state, that is, another command identification number "2", to the communication packets 2-1 and 2-2 and transmits the communication packets 2-1 and 2-2 to the switched network 500 thereby to place the command identification number "2" into a used state.

[0087]

At the transmission turn number 5, the communication device 400a sends the communication packet 1-3 for the communication command 1.

[0088]

At the transmission turn numbers 6, the communication device 400a sends the last communication packet 2-3 produced from the communication command 2 to the switched network 500. Since the communication packet 2-3 is the last packet produced from the communication command 2, the simultaneous communication command process number of the communication device 400a to the communication device 400b changes to 1 after the communication packet 2-3 is sent. Thus, it becomes possible to newly execute processing of another

communication command to the communication device 400b, and the command identification number "2" is placed into an unused state.

[0089]

At the transmission turn number 7, the communication device 400a newly starts processing of the communication command 3, and adds the command identification number "2" which is an unused command identification number to the communication packet 3-1 and sends the communication packet 3-1 to the switched network 500. At the transmission turn numbers 8 and 9, the communication device 400a sends the communication packets 1-4 and 1-5 produced from the communication command 1. Since the communication packet 1-5 is the last communication command produced from the communication command 1, the packet transmission processing of the communication command 1 is completed and the simultaneous command process number of the communication device 400a to the communication device 400b changes to 1. Thus, the command identification number "1" is placed into an unused state.

[0090]

At the transmission turn number 10, the communication device 400a sends the communication packet 3-2 of the communication command 3 to the switched network 500.

[0091]

At the transmission turn number 11, the communication device 400a adds the unused command identification number "1" to the communication packet 4-1 newly produced by the processing of the communication command 4 and sends the communication packet 4-1 to the switched network 500. Since the communication packet 4-1 is the last communication packet of the communication command 4, the command identification number "1" is placed into an unused state.

[0092]

At the transmission turn number 12, the last communication packet 3-3 of the communication command 3 is sent to the switched network 500, and the command identification number "2" is placed into an unused state.

[0093]

Subsequently, a process of the communication packet transmission section 450 which solves the problem of degradation of the TLB hit ratio caused by driving out of a TLB described hereinabove is described.

[0094]

Taking it into consideration that data transfer is characterized in that, in one communication command, the destination logical address in most cases increases monotonously and that a predetermined number of TLB entries are secured for each sending source in the reception section for a communication packet, the

transmission section 450 suppresses the number of communication commands to be processed simultaneously to the same destination to a number equal to or smaller than the limitation number described hereinabove to improve the TLB hit ratio. Further, in order to designate a TLB entry of the reception section 460 to be used by commands processed simultaneously by the transmission section 450, the command identification number 916 is added to each packet such that communication packets 900 produced with the same communication command 800 use the same TLB of the reception section 460 of the communication device 400.

[0095]

A configuration of the transmission section 450 is described in detail with reference to Fig. 17. The transmission section 450 includes a command processing section 451 for receiving a transmission command process starting instruction from the processor, extracting a transmission command from the main storage device 300 and transmitting the extracted transmission command to a packet production section, and a packet production section 452 for receiving the transmission command from the command processing section, converting a logical address of the transmission data buffer into a physical address using the STLB 470 to read out transmission data from the main storage device 300, producing a transmission packet from the read out data,

and transmitting the transmission packet to the switched network 500.

[0096]

Operation of the transmission section where the simultaneous transmission command number limitation is 2 is described in detail with reference to Fig. 18.

[0097]

Start of command process: The initial value of the in-process command number is "0".

[0098]

N010: If a communication command processing instruction is issued from the processor 100 to the command processing section 451, then the processing advances to step N100.

In any other case, the processing returns to step N010.

[0099]

N100: The command processing section 451 extracts a transmission command from the main storage device 300.

[0100]

N110: If a transmission command whose transmission is completed newly is included in those transmission commands whose transmission instruction to the packet production section 452 has been issued from the command processing section 451, then the processing advances to step N120. However, if a transmission

command whose transmission is completed newly is not found, then the processing advances to step N130.

[0101]

N120: The command processing section 451 receives a completion notification or notifications of a transmission command or commands from the packet production section 452 and subtracts the number of the completion notifications from the in-process command number in the command processing section 451. The "in-process command number - = completed command number" is a simplified representation of the "in-process command number = in-process command number - completed command number".

[0102]

N130: If the in-process command number is smaller than 2, then the processing advances to step N140. In any other case, the processing returns to step N110.

[0103]

N140: The communication command is transferred from the command processing section 451 to the packet production section 452.

[0104]

End of command process: The processing of the command processing section 451 for the one command is ended.

[0105]

The packet production section 452 having received the communication command from the command processing section 451 uses the STLB 370 to convert the sending source logical address 813 in the communication command 800 into a physical address, extracts transmission data of the length of the transfer length 814 from the main storage device 300, divides the data into divisional data of a prescribed length, produces packets individually from the divisional data and transmits the packets to the switched network 500.

[0106]

The simultaneous command issuance number limitation is restricted most significantly by the entry number of a TLB incorporated in hardware. In particular, the number of commands which can be processed simultaneously by the transmission section relies upon the numbers of entries of a TLB which can be incorporated on the reception side and the transmission side. If the transmission section holds a number of TLB entries equal to the number of commands which can be processed simultaneously, then a sufficient hit ratio of a TLB is obtained. On the reception side, if a number of TLB entries equal to the number defined by the number of commands which can be processed simultaneously x number of sending source computers is held, then a sufficient hit ratio of the TLB is obtained.

For example, if it is assumed that the

simultaneously processed command number is 2 and 10 computers are connected through the switched network 500, then it is sufficient as the TLB entry number to the reception side if it incorporates 2 x 10 = 20 entries. Further, if the simultaneously processed command number is 1, then when transfer of data of a great data size is carried out, transfer of succeeding data of a smaller data size is obliged to wait for a long period of time. Therefore, the simultaneously processed command number is normally set to 2 or more.

[0107]

Subsequently, an effect that the hit ratio is raised by the simultaneous command number limitation is described with reference to Figs. 15 and 16.

[0108]

First, operation of a reception side TLB where there is no simultaneous transmission command limitation is described in detail with reference to Fig. 15.

[0109]

In particular, Fig. 15 is a diagrammatic view illustrating operation where the TLB entry number on the reception side is 1 and the transmission command 1 produces two packets 1-1 and 1-2 while the transmission command 2 produces two packets 2-1 and 2-2 and consequently the transmission command 1 and the transmission command 2 individually transmit two packets. The destination addresses 813 of the

transmission command 1 and the transmission command 2 use different pages from each other, and the packets 1-1 and 1-2 are transferred to addresses in the same page while the packets 2-1 and 2-2 are transferred to addresses in the same page.

[0110]

Start

T11: The TLB prior to reception of a packet is in an invalid state.

P11: The packet 1-1 is received.

T12: TLB miss (miss for the first time)

T13: Conversion information for the transmission command 1 is registered into the TLB.

P12: The packet 2-1 is received.

T14: TLB miss (miss for the second time). The transmission command 2 and the transmission command 1 use different pages from each other.

T15: Conversion information for the transmission command 2 is registered into the TLB.

P13: The packet 1-2 is received.

T16: TLB miss (miss for the third time). The transmission command 1 and the transmission command 2 use different pages from each other.

T17: Conversion information for the transmission command 1 is registered into the TLB.

P14: The packet 2-2 is received.

T18: TLB miss (miss for the fourth time). The

transmission command 2 and the transmission command 1 use different paces from each other.

T19: Conversion information for the transmission command 2 is registered into the TLB.

End.

In the operation described above, a TLB miss occurs four times.

[0111]

Operation of the reception side TLB where there is a simultaneous transmission command limitation is described in detail with reference to Fig. 16.

[0112]

In particular, Fig. 16 is a diagrammatic view illustrating operation where the conditions are similar to those in the case of Fig. 15 except that the simultaneous command limitation number of the transmission side is 1. In Fig. 16, the TLB entry number on the reception side is 1 and the transmission command 1 produces two packets 1-1 and 1-2 while the transmission command 2 produces two packets 2-1 and 2-2 and consequently the transmission command 1 and the transmission command 2 individually transmit two packets. The destination addresses of the transmission command 1 and the transmission command 2 use different pages from each other, and the packets 1-1 and 1-2 are transferred to addresses in the same page while the packets 2-1 and 2-2 are transferred to addresses in the

same page.

[0113]

Start

T21: The TLB prior to reception of a packet is in an invalid state.

P21: The packet 1-1 is received.

T22: TLB miss (miss for the first time)

T23: Conversion information for the transmission command 1 is registered into the TLB.

P22: The packet 1-2 is received.

T24: TLB hit (hit for the first time). The packet 1-1 and the packet 1-2 use the same page.

T25: Conversion information for the transmission command 2 is registered into the TLB.

P23: The packet 2-1 is received.

T26: TLB miss (miss for the second time). The transmission command 1 and the transmission command 2 use different pages from each other.

T27: Conversion information for the transmission command 2 is registered into the TLB.

P24: The packet 2-2 is received.

T28: TLB hit (hit for the second time). The packet 2-1 and the packet 2-2 use the same page.

T29: Conversion information for the transmission command 2 is already registered in the TLB.

End.

In the present operation described above, a

TLB miss occurs twice, and a TLB hit occurs two times.

[0114]

In Fig. 15 where there is no command number limitation, a TLB hit occurs 0 time with respect to four packets, that is, the TLB hit ratio is 0 %. Meanwhile, in Fig. 16 where there is a command number limitation, a TLB hit occurs two times with respect to four packets, that is, the TLB hit ratio is 50 %. Accordingly, an effect that the hit ratio is improved by the command number limitation is achieved.

[0115]

[Effects of the Invention]

With the above-described configuration, the present invention has the following advantages.

[0116]

Since entries of a TLB are allocated independently of each other to communication packets from a plurality of sending sources, there is an advantage that a TLB entry is not driven out by a destination logical address of a communication packet from a different sending source communication device.

[0117]

Further, where the number of communication commands to be processed simultaneously from a sending source computer of communication packets to the same destination computer is to be limited, it is possible for the reception side of the communication packets to

suppress the number of TLB entries to be retained for one sending source to a number equal to or smaller than the limitation number and retain a number of TLB entries equal to the simultaneous process command number. Consequently, TLB entries corresponding to the communication commands being transmitted from the sending source computer continue to always be retained, and there is an advantage that the TLB hit ratio is raised.

[0118]

Where a process command identification number of the sending source communication device is applied to a communication packet to designate a TLB entry to be used by the reception section, one communication command being processed by the sending source communication device always uses the same TLB entry, and besides, the possibility that the destination logical address of one communication command in data transfer may increase monotonously is high. Consequently, there is an advantage that a sending source can cause processes of a plurality of communication commands to the same destination to be simultaneously executed and besides the TLB hit ratio is improved.

[Brief Explanation of the Drawings]

[Fig. 1]

Fig. 1 is a block diagram showing a computer system according to the present invention.

[Fig. 2]

Fig. 2 is a diagrammatic view illustrating a configuration of a TLB.

[Fig. 3]

Fig. 3 is a diagrammatic view illustrating an address conversion method.

[Fig. 4]

Fig. 4 is a diagrammatic view illustrating a configuration of a page table.

[Fig. 5]

Fig. 5 is a diagrammatic view illustrating a first TLB indexing method.

[Fig. 6]

Fig. 6 is a diagrammatic view illustrating a second TLB indexing method.

[Fig. 7]

Fig. 7 is a diagrammatic view illustrating a communication method.

[Fig. 8]

Fig. 8 is a diagrammatic view illustrating examples of a processing command of a communication device.

[Fig. 9]

Fig. 9 is a diagrammatic view illustrating an example of packet transmission by the communication device.

[Fig. 10]

Fig. 10 is a diagrammatic view illustrating a format of a communication command.

[Fig. 11]

Fig. 11 is a diagrammatic view illustrating a format of a communication packet.

[Fig. 12]

Fig. 12 is a block diagram showing an internal structure of a computer.

[Fig. 13]

Fig. 13 is a flowchart for explaining contents of the page table.

[Fig. 14]

Fig. 14 is a diagrammatic view for explaining contents of the page table.

[Fig. 15]

Fig. 15 is a diagrammatic view for explaining an effect that the hit ratio is improved by limitation to the number of simultaneous commands.

[Fig. 16]

Fig. 16 is a diagrammatic view for explaining an effect that the hit ratio is improved by limitation to the number of simultaneous commands.

[Fig. 17]

Fig. 17 is a block diagram showing a configuration of a transmission section 450.

[Fig. 18]

Fig. 18 is a flowchart illustrating operation

of the transmission section where the simultaneous transmission instruction number limitation is set to 2.

[Explanation of the Reference Numerals and Signs]

100a, 100b, 100z: computer

200a, 200b, 200z: processor

300a, 300b, 300z: main storage device

310: page table

320: physical page number

321: page entry validity flag

322: page readability attribute

323: page writability attribute

330: page entry

400: communication device

400a, 400b, 400z: communication device

410a, 410b, 410z: TLB (Translation Look aside Buffer)

410: TLB (Translation Look aside Buffer)

420: TLB entry validity flag

421: TPID (TLB Process ID)

422: TVPN (TLB Virtual Page Number)

423: TPPN (TLB Physical Page Number)

450: transmission section of communication device

451: command processing section of transmission section

452: packet production section of

transmission section

460: reception section of communication device

470: TLB used by transmission section

500: switched network

800: communication command

810: command code

811: destination computer number

812: destination process number

813: destination logical address

814: transfer length

815: sending source computer number

816: sending source process number

817: sending source logical address

900: communication packet

910: command code

911: destination computer number

912: PPID (Packet Process ID)

913: PVA (Packet Virtual Address)

914: in-packet data length

915: sending source computer number

916: command identification number

917: transfer data

921: PVPN (Packet Virtual Page Number)

922: Offset (virtual address offset)

932: after-conversion physical address

[Document Name] Abstract

[Abstract]

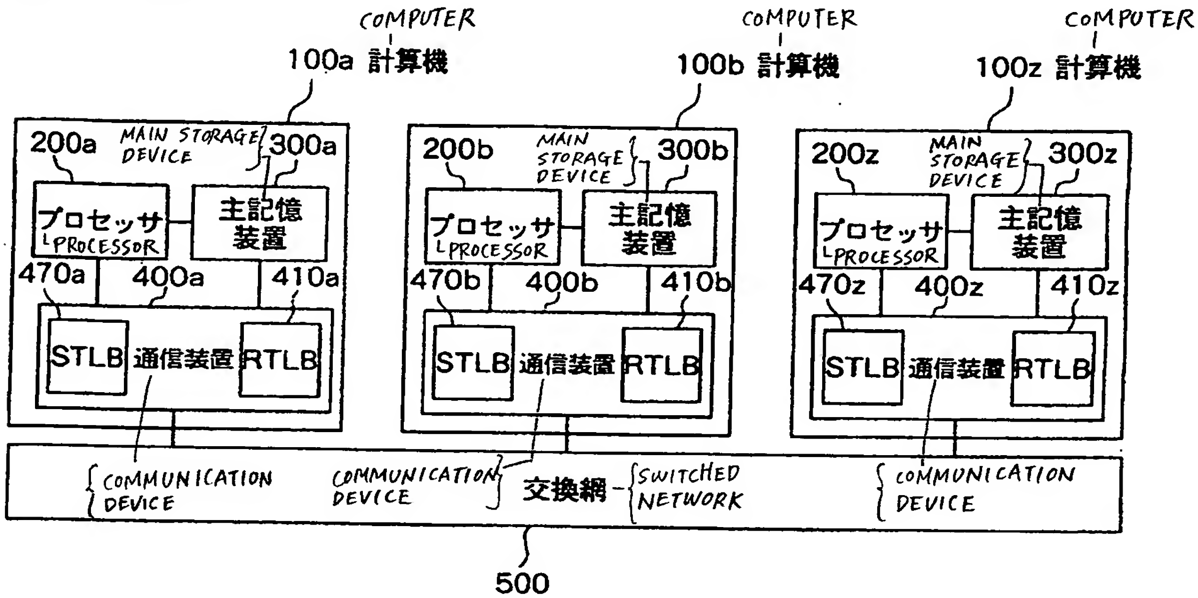
[Problem] In a method of indexing a TLB entry with a conversion object logical address in a TLB, it is difficult to improve the hit ratio of the TLB.

[Solving Means] There is provided a data transfer method executed in a network system in which a plurality of computers are connected to each other through a packet switched network. In this method, each of the plurality of computers includes a main storage device, a processor for issuing a communication process command, and a communication device for processing the communication command from the processor and communicating with another one of the computers through the packet switched network. The communication device includes a transmission section for transmitting a communication to the switched network and a reception section for receiving a communication from the switched network, and each of the transmission section and the reception section includes a TLB for retaining a plurality of TLB entries. The processor issues the communication command which includes information of the computer of the sending source. The reception section determines one of the TLB entries which is to be used in accordance with the computer of the sending source.

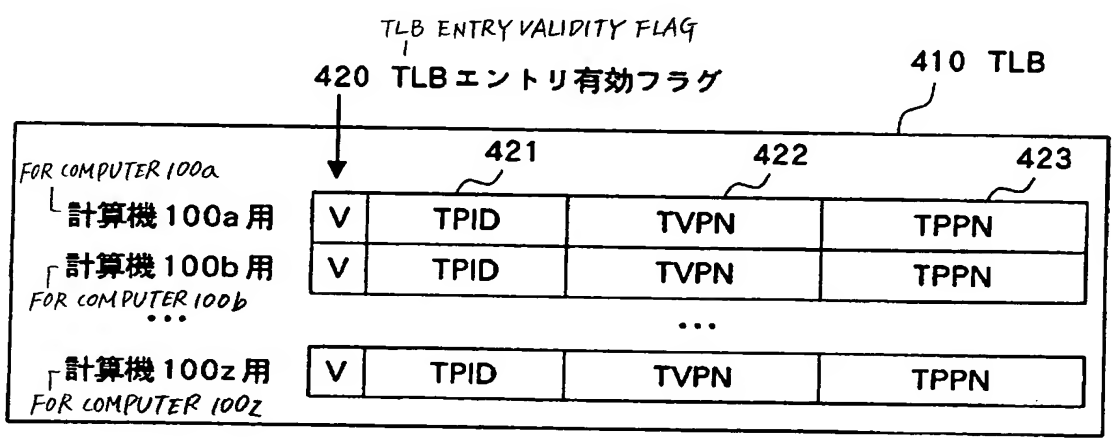
[Selected Figure] Fig. 6

【書類名】　図面 - DRAWINGS
└ DOCUMENT NAME

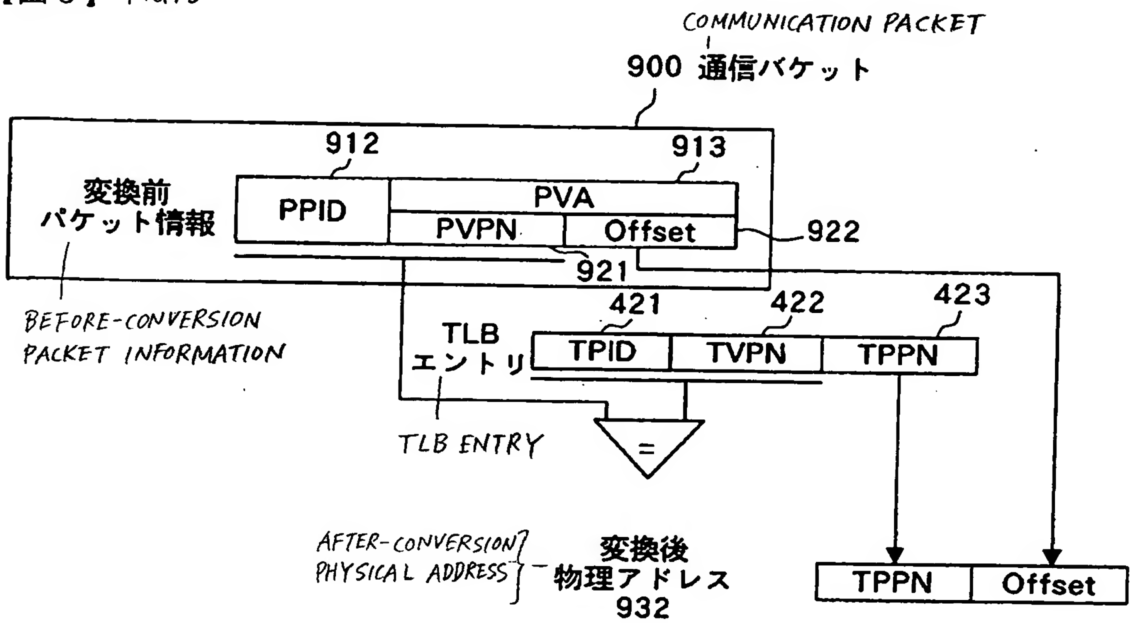
【図１】- FIG.1



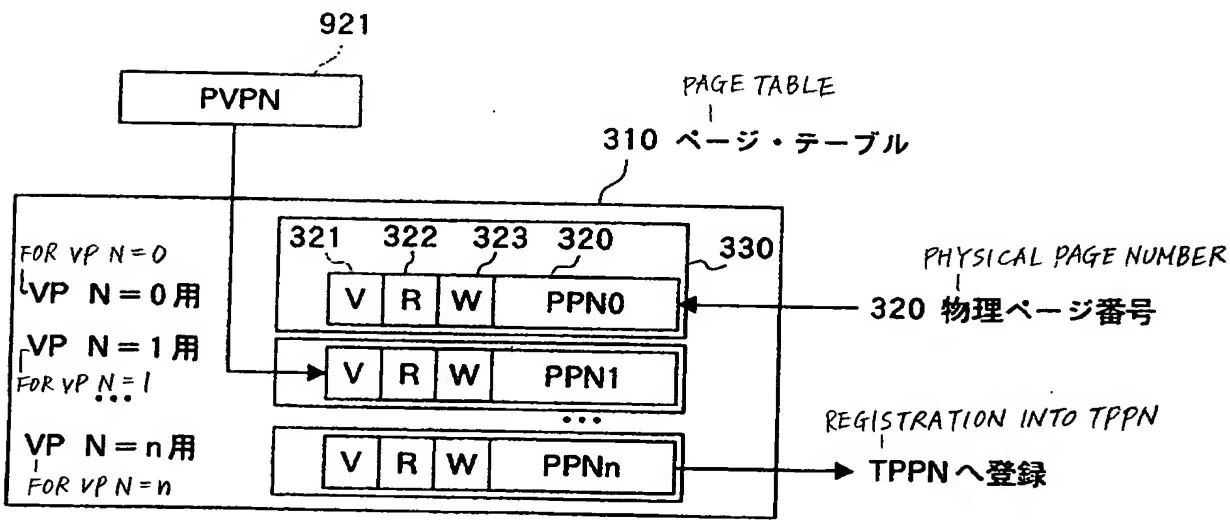

【図２】- FIG. 2



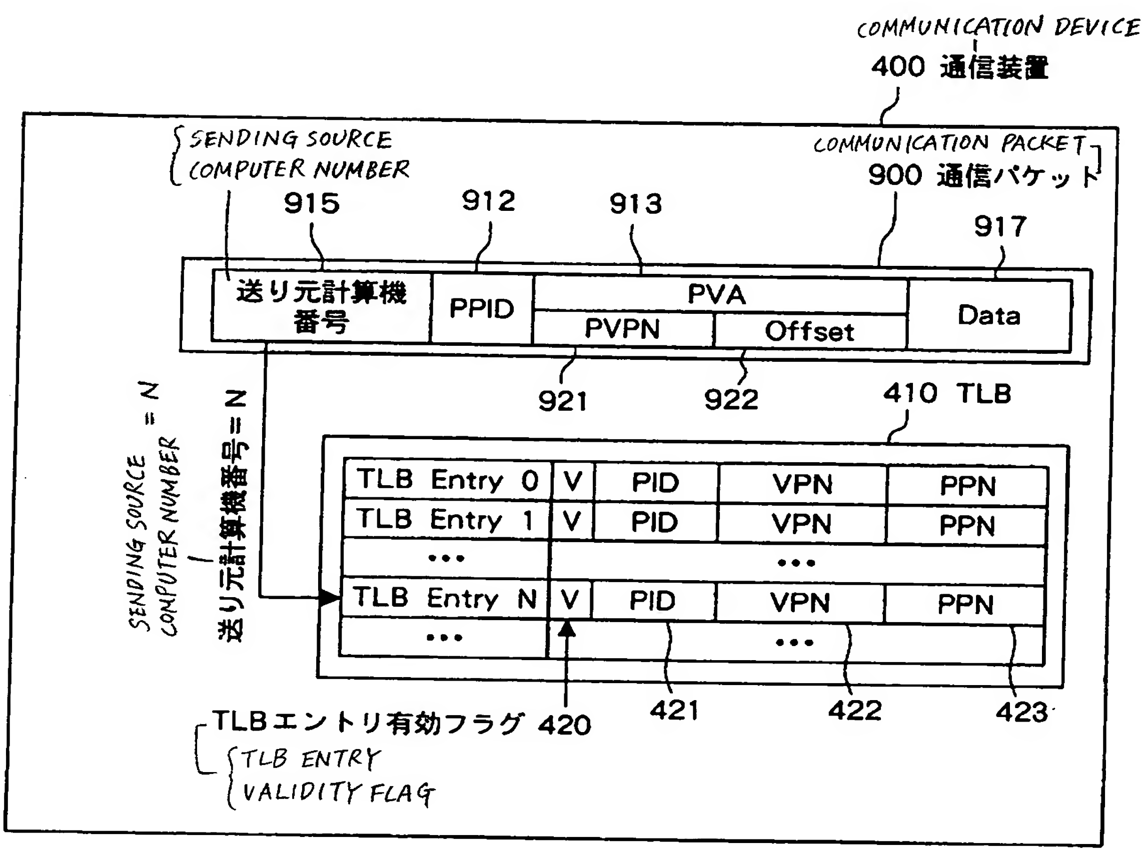
【図３】- FIG. 3



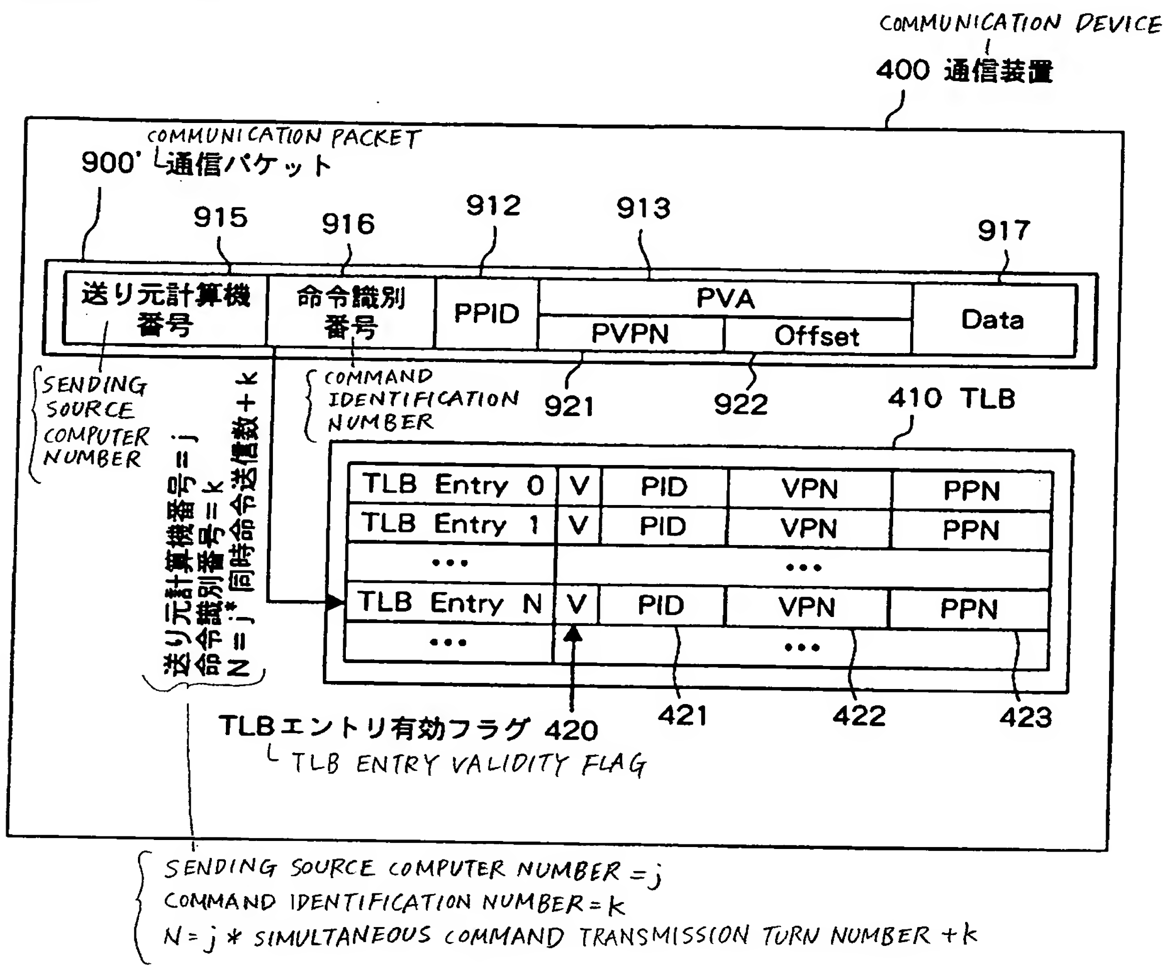

【図４】- FIG. 4



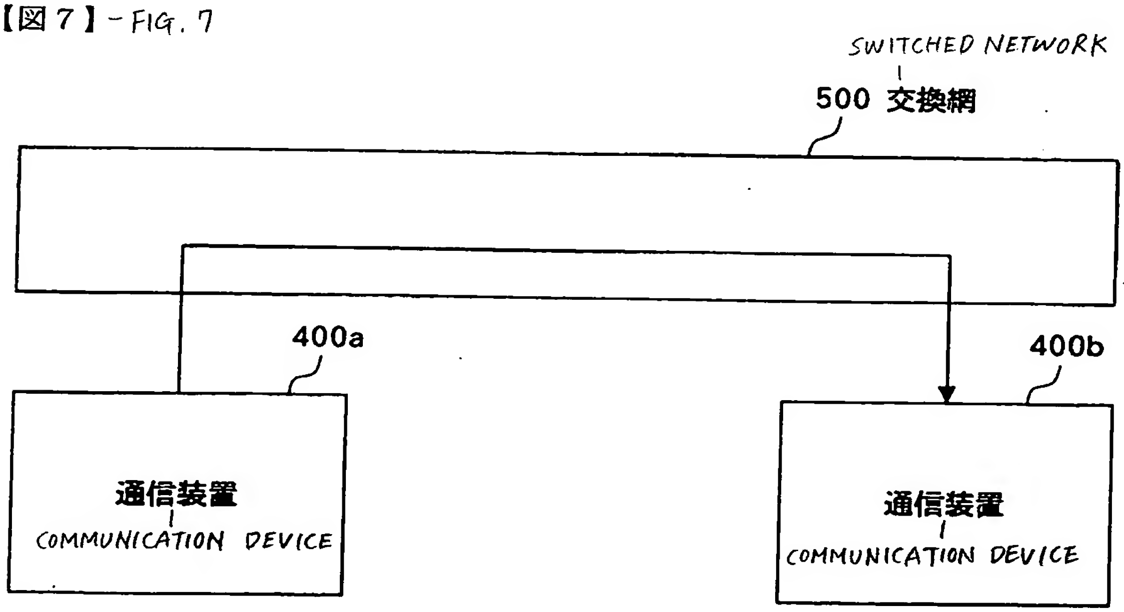
【図５】－FIG. 5


COMMUNICATION DEVICE
400 通信装置
COMMUNICATION PACKET
900 通信パケット
SENDING SOURCE
COMPUTER NUMBER
915
912
913
917
送り元計算機番号
PPID
PVA
PVPN
Offset
Data
921
922
410 TLB
送り元計算機番号＝N
SENDING SOURCE COMPUTER NUMBER = N
TLB Entry 0
TLB Entry 1
TLB Entry N
V
PID
VPN
PPN
TLBエントリ有効フラグ 420
TLB ENTRY VALIDITY FLAG
421
422
423

【図６】- FIG. 6




【図７】- FIG. 7



【図８】－FIG. 8

| 命令 COMMAND | 宛先 DESTINATION | パケット数 PACKET NUMBER |
|---|---|---|
| 通信命令１ | 400b | 5 |
| 通信命令２ | 400b | 3 |
| 通信命令３ | 400b | 3 |
| 通信命令４ | 400b | 1 |

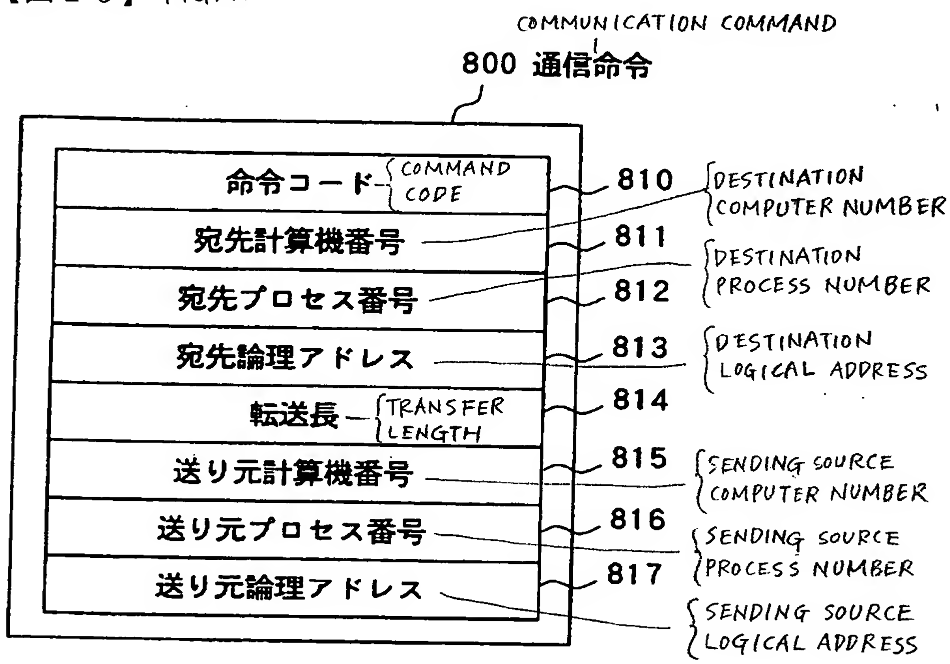
COMMUNICATION COMMAND 1
COMMUNICATION COMMAND 2
COMMUNICATION COMMAND 3
COMMUNICATION COMMAND 4

【図９】－FIG. 9

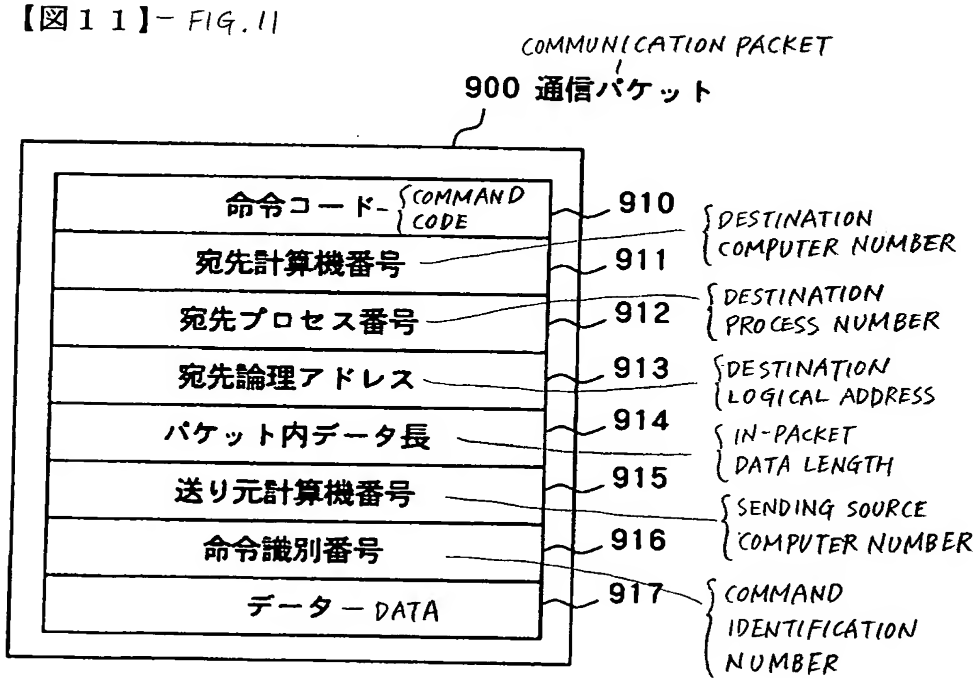
| 送信順序 TRANSMISSION TURN NUMBER | 通信命令 COMMUNICATION COMMAND | 通信パケット COMMUNICATION PACKET | 通信パケット内命令識別番号 COMMUNICATION PACKET INTERNAL COMMAND IDENTIFICATION NUMBER | 通信命令内最終パケット LAST PACKET IN COMMUNICATION COMMAND |
|---|---|---|---|---|
| 1 | 通信命令１ | 通信パケット１－１ | 1 | No |
| 2 | 通信命令１ | 通信パケット１－２ | 1 | No |
| 3 | 通信命令２ | 通信パケット２－１ | 2 | No |
| 4 | 通信命令２ | 通信パケット２－２ | 2 | No |
| 5 | 通信命令１ | 通信パケット１－３ | 1 | No |
| 6 | 通信命令２ | 通信パケット２－３ | 2 | Yes |
| 7 | 通信命令３ | 通信パケット３－１ | 2 | No |
| 8 | 通信命令１ | 通信パケット１－４ | 1 | No |
| 9 | 通信命令１ | 通信パケット１－５ | 1 | Yes |
| 10 | 通信命令３ | 通信パケット３－２ | 2 | No |
| 11 | 通信命令４ | 通信パケット４－１ | 1 | Yes |
| 12 | 通信命令３ | 通信パケット３－３ | 2 | Yes |

COMMUNICATION COMMAND 1
COMMUNICATION COMMAND 1
COMMUNICATION PACKET 1-1
COMMUNICATION PACKET 1-2
COMMUNICATION PACKET 2-1
COMMUNICATION PACKET 2-2
COMMUNICATION PACKET 1-3
COMMUNICATION PACKET 2-3
COMMUNICATION PACKET 3-1
COMMUNICATION PACKET 1-4
COMMUNICATION PACKET 1-5
COMMUNICATION COMMAND 3
COMMUNICATION COMMAND 2
COMMUNICATION PACKET 3-2
COMMUNICATION COMMAND 4
COMMUNICATION COMMAND 2
COMMUNICATION PACKET 4-1
COMMUNICATION COMMAND 3
COMMUNICATION COMMAND 1
COMMUNICATION PACKET 3-3
COMMUNICATION COMMAND 1
COMMUNICATION COMMAND 1
COMMUNICATION COMMAND 3
COMMUNICATION COMMAND 2

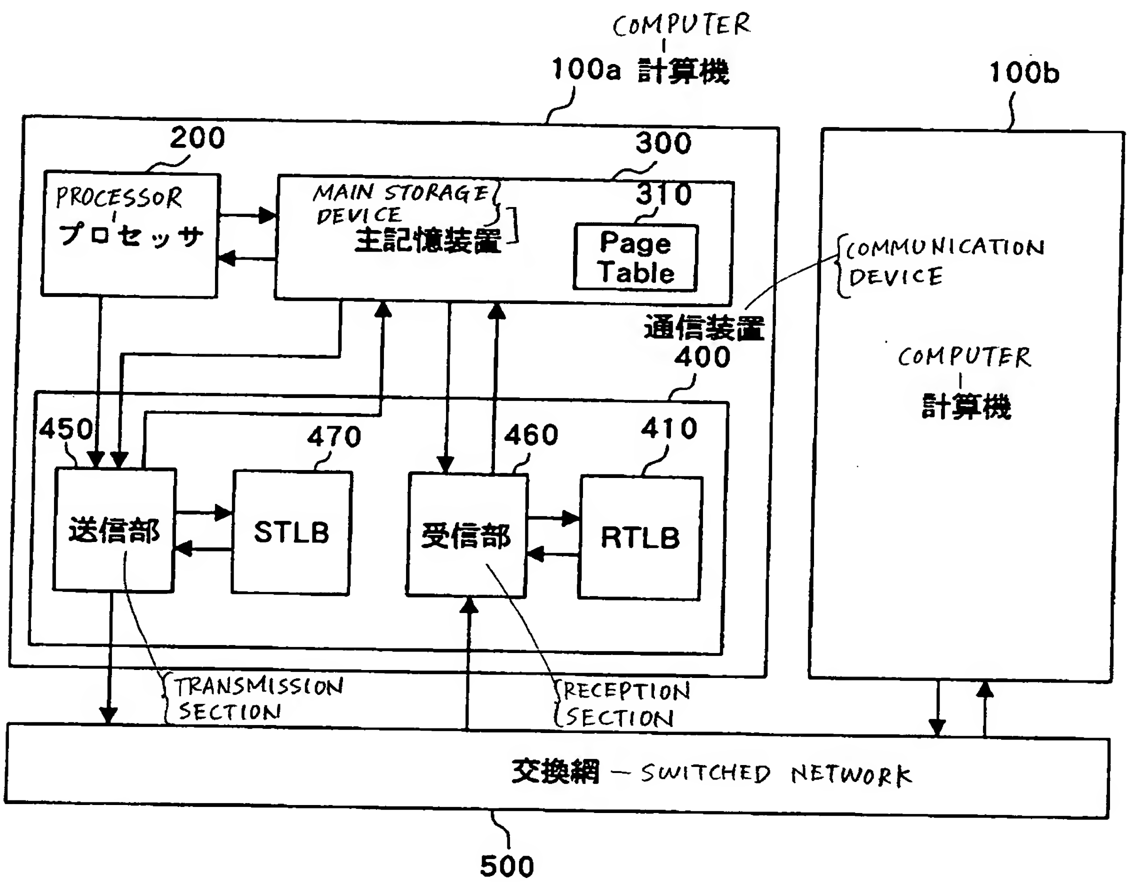
【図１０】- FIG. 10



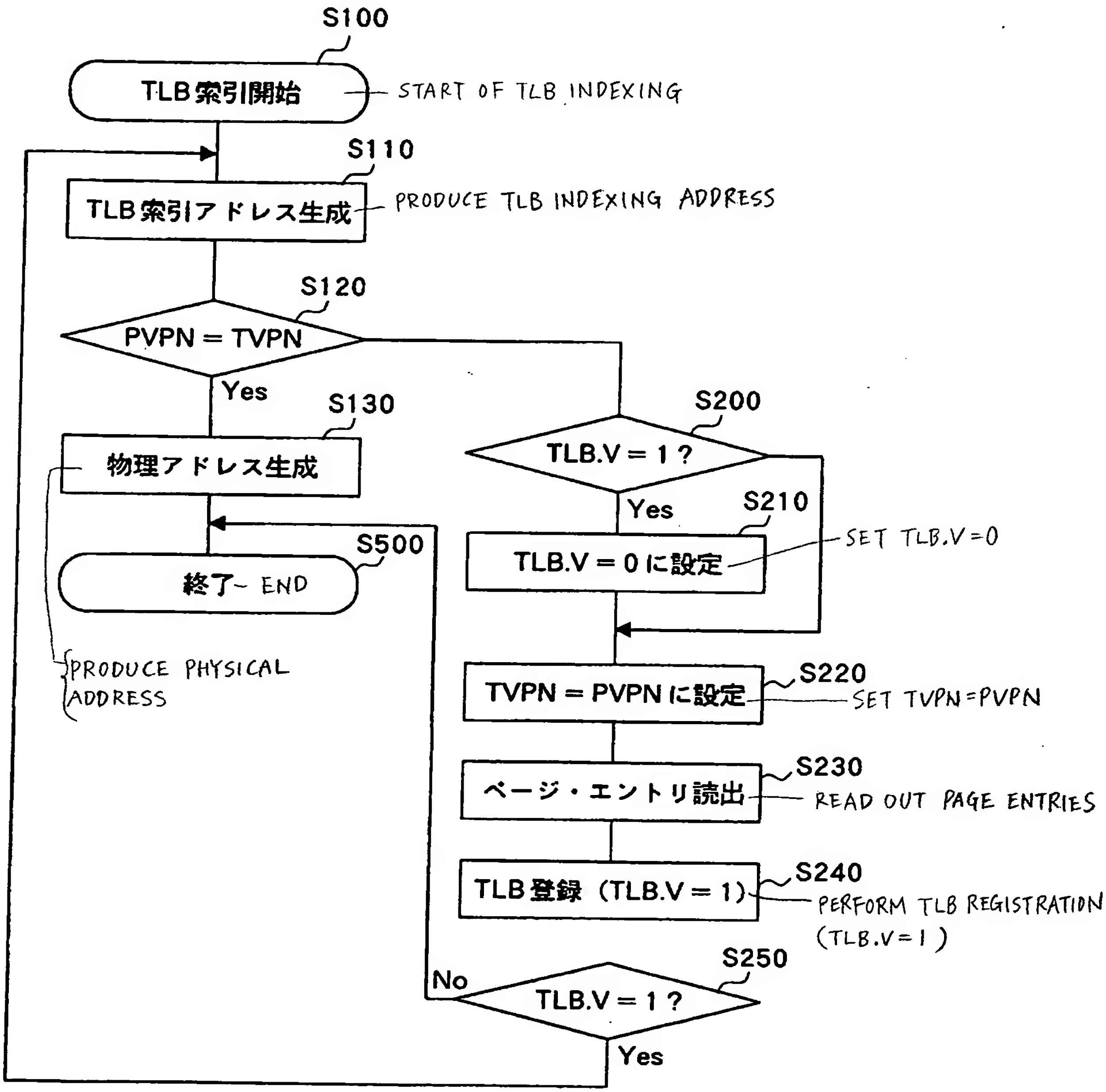

【図１１】- FIG. 11



【図１２】-FIG.12


COMPUTER
100a 計算機
100b
200
PROCESSOR
プロセッサ
300
MAIN STORAGE DEVICE
主記憶装置
310
Page Table
COMMUNICATION DEVICE
通信装置
400
COMPUTER
計算機
450
470
460
410
送信部
STLB
受信部
RTLB
TRANSMISSION SECTION
RECEPTION SECTION
交換網 — SWITCHED NETWORK
500

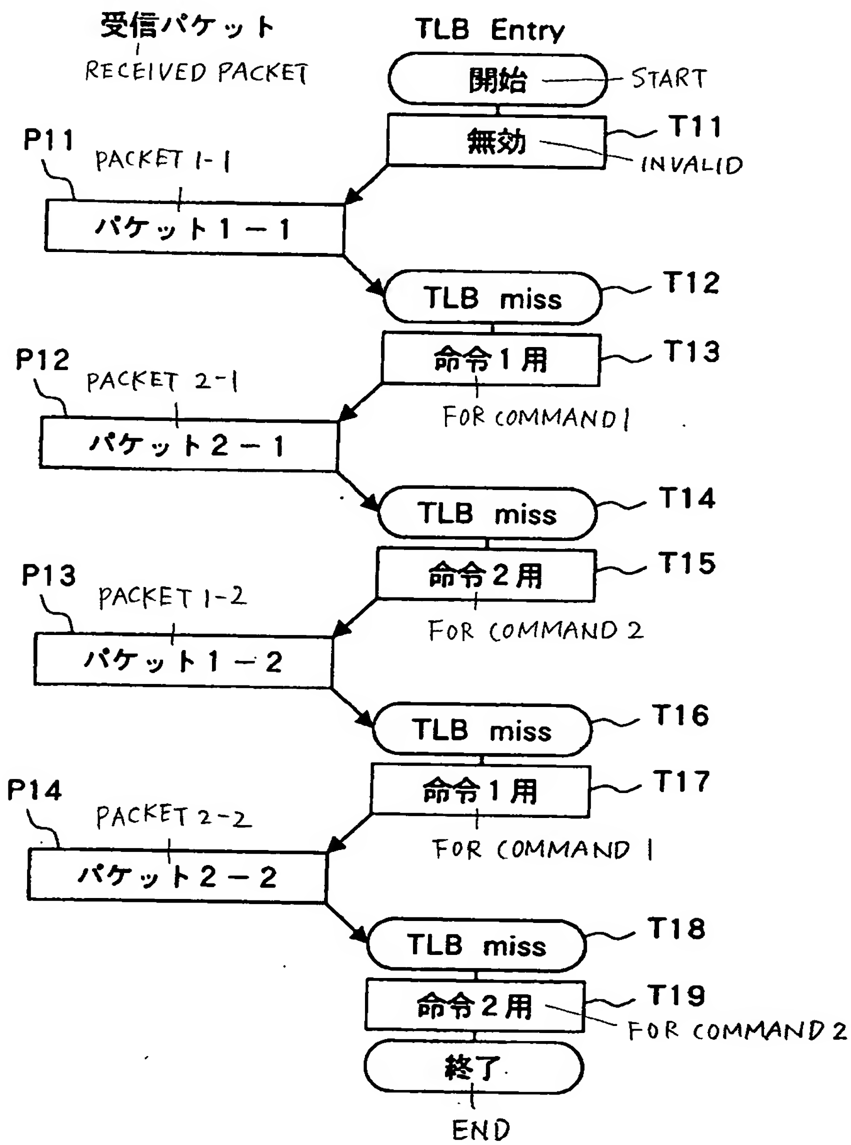
【図１３】－FIG.13


S100
TLB索引開始
START OF TLB INDEXING
S110
TLB索引アドレス生成
PRODUCE TLB INDEXING ADDRESS
S120
PVPN＝TVPN
Yes
S130
物理アドレス生成
PRODUCE PHYSICAL ADDRESS
S500
終了～END
S200
TLB.V＝１？
Yes
S210
TLB.V＝０に設定
SET TLB.V=0
S220
TVPN＝PVPNに設定
SET TVPN=PVPN
S230
ページ・エントリ読出
READ OUT PAGE ENTRIES
S240
TLB登録（TLB.V＝１）
PERFORM TLB REGISTRATION (TLB.V=1)
S250
TLB.V＝１？
No
Yes

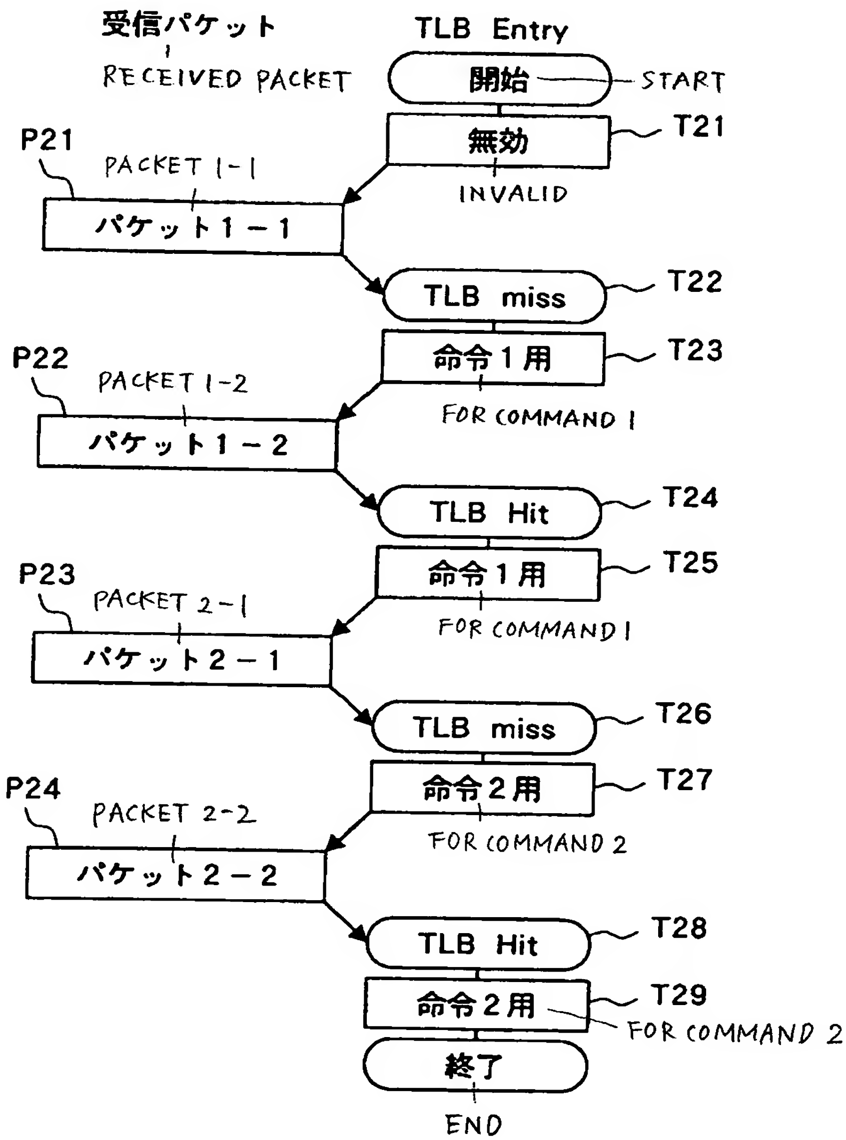
【図１４】-FIG. 14

| 送信順序 (TRANSMISSION TURN NUMBER) | 通信命令 (COMMUNICATION COMMAND) | 通信パケット (COMMUNICATION PACKET) | 通信パケット内命令識別番号 (COMMUNICATION PACKET INTERNAL COMMAND IDENTIFICATION NUMBER) | 通信命令内最終パケット (LAST PACKET IN COMMUNICATION COMMAND) |
|---|---|---|---|---|
| 1 | 通信命令１ (COMMUNICATION COMMAND 1) | 通信パケット１－１ (COMMUNICATION PACKET 1-1) | 1 | No |
| 2 | | 通信パケット１－２ (COMMUNICATION PACKET 1-2) | 1 | No |
| 3 | | 通信パケット１－３ (COMMUNICATION PACKET 1-3) | 1 | No |
| 4 | | 通信パケット１－４ (COMMUNICATION PACKET 1-4) | 1 | No |
| 5 | | 通信パケット１－５ (COMMUNICATION PACKET 1-5) | 1 | Yes |
| 6 | 通信命令２ (COMMUNICATION COMMAND 2) | 通信パケット２－１ (COMMUNICATION PACKET 2-1) | 2 | No |
| 7 | | 通信パケット２－２ (COMMUNICATION PACKET 2-2) | 2 | No |
| 8 | | 通信パケット２－３ (COMMUNICATION PACKET 2-3) | 2 | Yes |
| 9 | 通信命令３ (COMMUNICATION COMMAND 3) | 通信パケット３－１ (COMMUNICATION PACKET 3-1) | 2 | No |
| 10 | | 通信パケット３－２ (COMMUNICATION PACKET 3-2) | 2 | No |
| 11 | | 通信パケット３－３ (COMMUNICATION PACKET 3-3) | 2 | Yes |
| 12 | 通信命令４ (COMMUNICATION COMMAND 4) | 通信パケット４－１ (COMMUNICATION PACKET 4-1) | 1 | Yes |

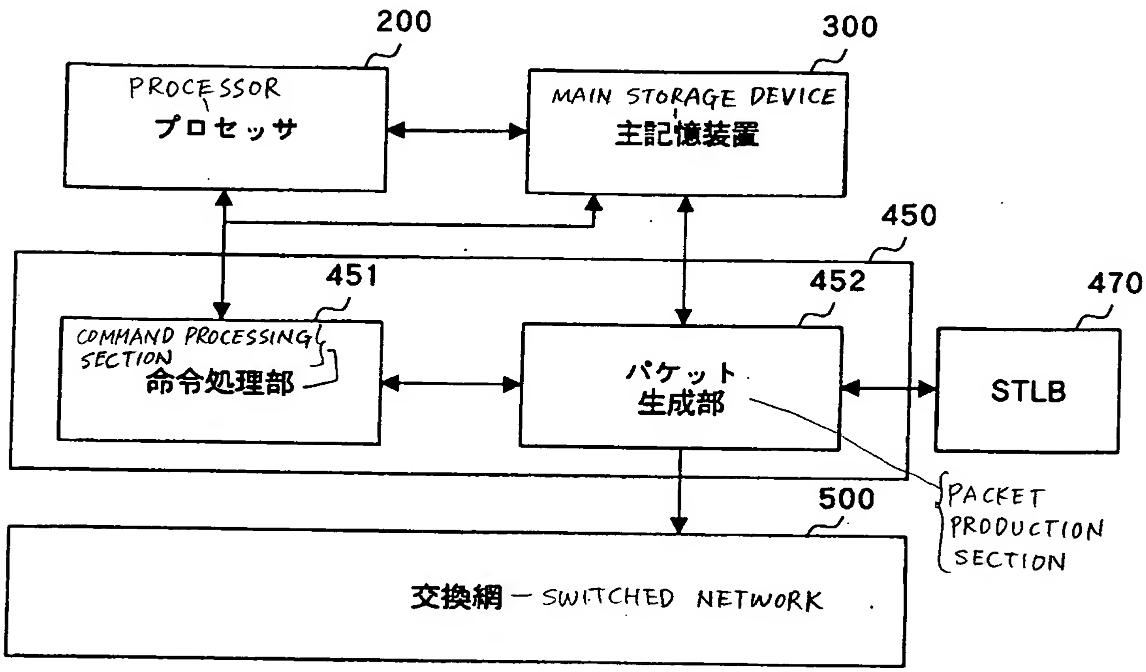
【図１５】-FIG.15


受信パケット
RECEIVED PACKET
TLB Entry
開始
START
無効
T11
INVALID
P11
PACKET 1-1
パケット１－１
TLB miss
T12
命令１用
T13
FOR COMMAND 1
P12
PACKET 2-1
パケット２－１
TLB miss
T14
命令２用
T15
FOR COMMAND 2
P13
PACKET 1-2
パケット１－２
TLB miss
T16
命令１用
T17
FOR COMMAND 1
P14
PACKET 2-2
パケット２－２
TLB miss
T18
命令２用
T19
FOR COMMAND 2
終了
END

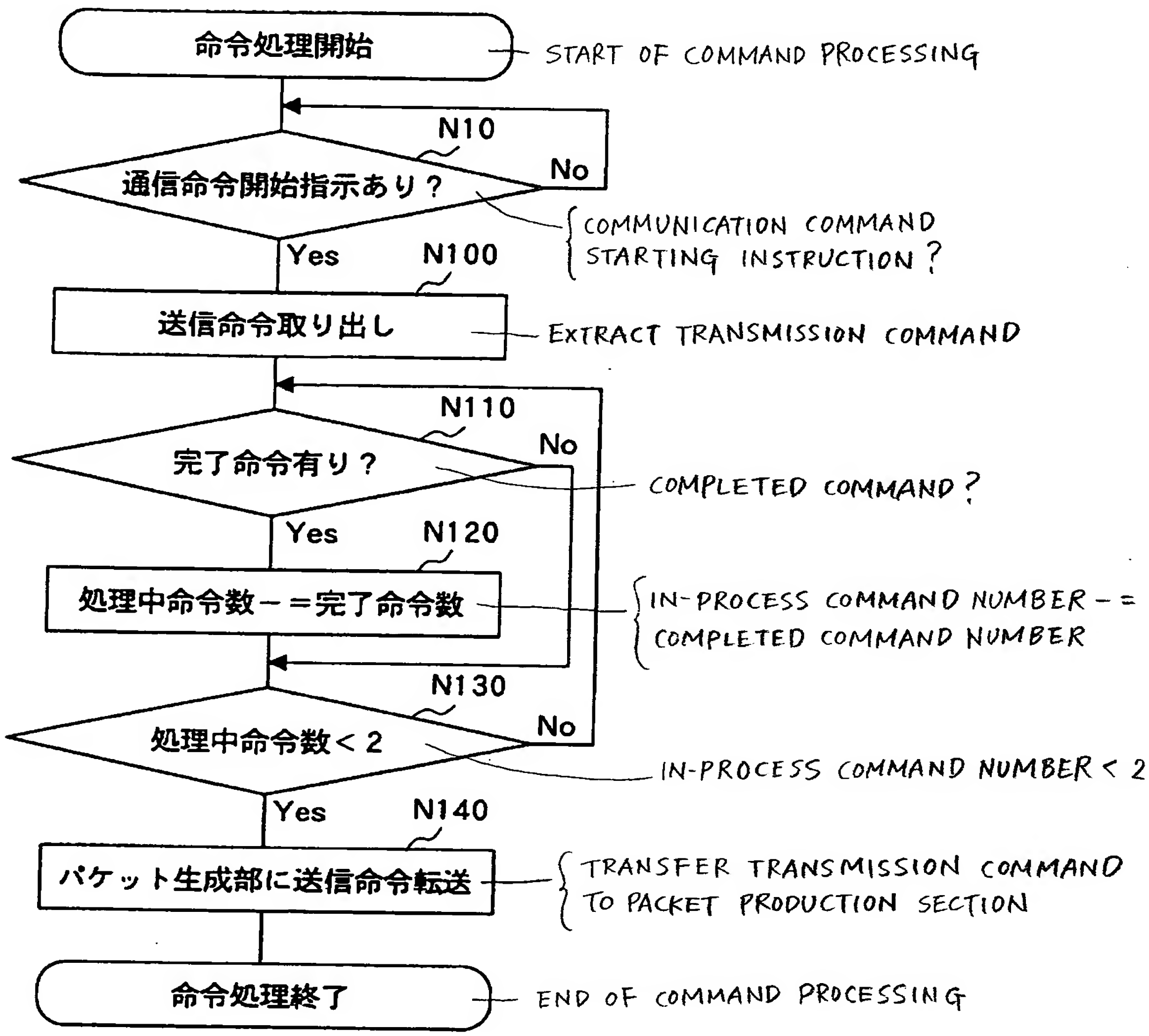
【図１６】－FIG.16


受信パケット
RECEIVED PACKET
TLB Entry
開始
START
無効
INVALID
T21
P21
PACKET 1-1
パケット１－１
TLB miss
T22
命令１用
T23
FOR COMMAND 1
P22
PACKET 1-2
パケット１－２
TLB Hit
T24
命令１用
T25
FOR COMMAND 1
P23
PACKET 2-1
パケット２－１
TLB miss
T26
命令２用
T27
FOR COMMAND 2
P24
PACKET 2-2
パケット２－２
TLB Hit
T28
命令２用
T29
FOR COMMAND 2
終了
END

【図１７】－FIG. 17


200
PROCESSOR
プロセッサ
300
MAIN STORAGE DEVICE
主記憶装置
450
451
COMMAND PROCESSING SECTION
命令処理部
452
パケット生成部
PACKET PRODUCTION SECTION
470
STLB
500
交換網 － SWITCHED NETWORK

【図１８】－FIG.18


命令処理開始
START OF COMMAND PROCESSING
N10
通信命令開始指示あり？
No
COMMUNICATION COMMAND STARTING INSTRUCTION ?
Yes
N100
送信命令取り出し
EXTRACT TRANSMISSION COMMAND
N110
完了命令有り？
No
COMPLETED COMMAND ?
Yes
N120
処理中命令数－＝完了命令数
IN-PROCESS COMMAND NUMBER -= COMPLETED COMMAND NUMBER
N130
処理中命令数＜２
No
IN-PROCESS COMMAND NUMBER < 2
Yes
N140
パケット生成部に送信命令転送
TRANSFER TRANSMISSION COMMAND TO PACKET PRODUCTION SECTION
命令処理終了
END OF COMMAND PROCESSING